2 Project overview

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Cover photograph: Megan Parry monitoring vegetation growth

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APPENDIX

GLOSSARY

Below are key terms that are used in this section.

Key term	Definition
Environmental Requirements	The Ranger Environmental Requirements are attached to the s.41 Authority and set out Primary and Secondary Environmental Objectives, which establish the principles by which the Ranger operation is to be conducted, closed and rehabilitated and the standards that are to be achieved.
Water management technology	Refer Appendix 2.1 for the definitions for common terms used in water management.
Reference Level	Reference Level abbreviated to RL. Denotes a specific elevation relative to mean sea level and is regularly used to identify the height or depth of plan or mine infrastructure – e.g. the height of the RWD or depth of Pit 3
Release Plan Calculator	Basic mass balance equation model used to assist with the prediction of changes in water quality between upstream (MCUS) and downstream (MG009) monitoring points. The RPC is used to determine when it is appropriate to actively release water from the minesite
Water Management System	The infrastructure, operations and procedures required to manage water at Ranger which includes capturing, storing, transferring, treating and disposing volumes of water.

ABBREVIATIONS & ACRONYMS

Below are abbreviations and acronyms that are used in this section.

Abbreviation/ Acronym	Description
AAEC	Australian Atomic Energy Commission
ARR	Alligator Rivers Region
ARRAC	Alligator Rivers Region Advisory Committee
ARRTC	Alligator Rivers Region Technical Committee
BC	Brine Concentrator
CB2	Collection Basin 2 – also denotes other collection basins on site – e.g. CB7
CCLAA	Corridor Creek Land Application Area
CCWLF	Corridor Creek Wetland Filter
DJKPS12	Djalkmarra Pump Station 12
DJKRP	Djalkmarra Release Point
DLAA	Djalkmarra Land Application Area
EIS	Environmental Impact Statement
EPIP Act	*Environmental Protection (Impact of Proposal) Act 1974*
ER	Environmental Requirements

Abbreviation/ Acronym	Description
ERA	Energy Resources of Australia Ltd
ERISS	Environmental Research Institute of the Supervising Scientist
EZ	Electrolytic Zinc Company of Australasia Ltd
FLV 7	Final Landform Design Model Version 7
GC2	Georgetown Creek 2
GCMBL	Georgetown Creek Median Bund Leveline
ha	hectare
HDS	High Density Sludge
JELAA	Jabiru East Land Application Area
LAA	Land Application Area
M t	Million Tonnes
NLC	Northern Land Council
NT	Northern Territory
NP	National Park
OBS	Osmoflow Brine Squeezer
Peko	Peko-Wallsend Operations Ltd
Pit 1	Walem Madjawulu 1
PFAS	Perfluoroalkyl and Polyfluoroalkyl Substances
R3 Deep	Ranger 3 Deep
RL	Reference Level
RP1	Retention Pond 1 - also denotes other retention ponds used on site – e.g. RP2, RP3, RP6
RP1Ext	Retention Pond 1 Extension
RPA	Ranger Project Area
RPC	Release Plan Calculator
RWD	Ranger Water Dam formerly the Tailings Storage Facility (TSF)
RWMP	Ranger Water Management Plan
S41	Section 41 Authority
SSB	Supervising Scientist Branch
TSF	Former Tailings Storage Facility now Ranger Water Dam (RWD)
WTP	Water Treatment Plant

2 PROJECT OVERVIEW

The purpose of this section is to provide background information on the history and status of the Ranger Mine project, and current mine site activities. Table 2-1 provides a timeline of events and key milestones for the mine.

Table 2-1 Ranger Mine timeline

Date	Description of Event / Milestone
1969	Ranger orebodies discovered by joint ventures Electrolytic Zinc Company of Australasia Ltd (EZ) and Peko-Wallsend Operations Limited (Peko).
1974	The Australian Government, through the Australian Atomic Energy Commission, agrees to finance 72.5 per cent of the project and sell the uranium, with 50 percent of the net proceeds distributed to the joint ventures.
1974	February: Submission of Environmental Impact Statement (and supporting material) under the Australian Government's *Environmental Protection (Impact of Proposal) Act 1974*.
1975	May: Submission of Supplements 1 and 2 to Environmental Impact Statement (EIS).
1975	The Ranger Uranium Environmental Inquiry (Fox *et al.* 1976) is established.
1977	Final Fox report (Fox *et al.* 1976, 1977) recommends that uranium mining proceed.
1977	Much of the Alligator Rivers Region (ARR) was declared a National Park (NP) and Aboriginal people were given a major role in the management of Kakadu NP.
1978	Title to the Ranger Project Area (RPA) was granted to the Kakadu Aboriginal Land Trust, in accordance with the Commonwealth *Aboriginal Land Rights (Northern Territory) Act 1976* (Aboriginal Land Rights Act) and the Commonwealth Government entered an agreement with the Northern Land Council (NLC) to permit mining to proceed. The Supervising Scientist position is established under the *Environment Protection (Alligator Rivers Region) Act 1978*.
1979	S41 Authority under the Australian *Atomic Energy Act 1953* is issued. Construction at Ranger commences.
1980	Energy Resources of Australia Limited is established as a public company. It was the largest public float in Australian history at the time. Using open cut methods, mining of Ranger Pit 1 orebody commences in May 1980.
1981	The first drum of uranium oxide is produced on 13 August 1981.
1994	Mining of Ranger Pit 1 orebody is completed in December, after recovering 19.78 million tonnes (M t) of ore.
1996	Final approval to mine Ranger Pit 3 orebody is received from the Northern Territory Government in May.
1997	Open cut mining of orebody 3 commences in July 1997, with mining expected to continue until at least 2009.
2000	Rio Tinto acquires North Limited, the previous major shareholder in ERA.

Date	Description of Event / Milestone
2006	October: ERA announces an increase in Ranger Mine's reserves as a result of a reduction in cut-off grade of stockpiled and yet to be mined ores for processing, adding approximately six years to the predicted life of processing at Ranger to 2020.
2007	September: ERA announces an extension to the Ranger operating Pit 3, extending mining at Ranger until 2021. ERA also announces expenditure for a pre-feasibility study to examine options to extend the mine further and to increase production from the processing plant.
2008	November: ERA announces a significant mineral exploration target defined at Ranger 3 Deeps of 15 to 20 million tonnes with a potential for 30,000 to 40,000 tonnes of contained uranium oxide.
2009	April: The laterite treatment plant was commissioned to extract uranium from weathered ores (referred to as laterite ores) that are unable to be processed through the existing processing plant.
2011	August: The ERA Board approves the construction of an exploration decline to conduct underground exploration drilling of Ranger 3 Deeps and to explore areas adjacent to the Ranger 3 Deeps resource.
2011	October: The ERA Board announced an accelerated renounceable entitlement offer (Entitlement Offer) of new ERA ordinary shares to all eligible shareholders at an offer price of $1.53 per new share. The Entitlement Offer was successfully completed on 15 November 2011 with ERA raising its target amount of $500 million. The funds to be used to progress the implementation of ERA’s strategic initiatives including the construction of a brine concentrator, construction of an exploration decline for the Ranger 3 Deeps resource and an expanded surface exploration on the Ranger Project Area.
2012	ERA approved the design, construction, and commissioning of a Brine Concentrator facility at Ranger.
2012	Works began on the construction of Phase 1 of the Ranger 3 Deeps exploration decline. ERA engaged MacMahon Holdings Limited to construct the 2.2-kilometre decline.
2012	June: The ERA Board approved expenditure to conduct a prefeasibility study on the potential Ranger 3 Deeps mine. The study to be conducted from 2012 until 2014 inclusive.
2012	Onsite water management was boosted to expand capacity beyond potential flood levels, with the completion of Retention Pond 6 and Ranger Water Dam (RWD) formerly Tailings Storage Facility (TSF) wall lift.
2012	Construction of a new levee to guard Pit 3 from Magela Creek in the event of a large flood event.
2012	Cessation of open cut mining in Pit 3. Commencement of Pit 3 backfill activities.
2013	Finalised the Ranger Mining Agreement with Mirarr Traditional Owners and implementation of a Relationship Committee.
2013	The operation submitted a referral for the Ranger 3 Deeps mine under the *Environment Protection and Biodiversity Conservation Act 1999.*

Date	Description of Event / Milestone
2013	Placement of waste rock over Pit 1 tailings to assist in ongoing dewatering of Pit 1. Approximately 70 per cent of the pre-load of waste rock was completed in 2013.
2013	Construction of the Brine Concentrator was completed. Commissioning tests and verification phase commenced.
2013	Backfill of 22.8 M t of waste material into Pit 3 in preparation for the planned transfer of tailing from the RWD and processing plant and storage of brines from the Brine Concentrator (BC).
2013	Phase 1 of the Ranger 3 (R3) Deep exploration decline continued with 1,900 metres of tunnel development and 13.9 kilometres of underground exploration drilling completed.
2014	Pit 3 under fill drainage layer and extraction pumping system installed.
2014	Construction of the tailings dredge completed.
2015	Pit 3 brine injection piping and infrastructure installed and commissioned.
2015	Tailings dredge, tailings transfer and water recovery/pumping infrastructure commissioned.
2016	All production tailings directed to Pit 3.
2017	April: Regulatory approval permitting ERA to begin the final stages of backfill in Pit 1 was obtained and this work has commenced.
2018	Laterite plant ceased operation due to exhaustion of laterite ore. Laterite plant placed under care and awaiting demolition as part of the site closure project.
2019	Ministerial approval to commence decommissioning of the R3 Deeps exploration decline.
2020	The High Density Sludge (HDS) plant application was submitted in October 2019 to gain approval for the release of partially treated process water into the pond water circuit. Approval was received on 19 February 2020.
2020	The application to utilise the Osmoflow Brine Squeezer (OBS) for the treatment of process water (as well as pond water for which the OBS is already approved to treat) was submitted on 5 May 2020. Approval to commence trialling the treatment of pond water through the OBS was received on 22 June 2020.
2020	The application to leave the subfloor of the RWD *in situ,* rather than to remove and transfer into Pit 3, was submitted on 16 March 2020. An updated version following stakeholder comments was submitted on 15 June 2020.
2020	Approval received July 2020 to leave the subfloor of the RWD *in-situ*.
2021	Production at the Ranger Mine ceased on 8 January 2021. This concluded processing activities on the RPA after 40 years of operation.
2021	Completion of dredging for tailing transfer from the RWD to Pit 3.
2021	Decommissioning of Processing Plant.
2021	Commenced planting on the backfilled surface of Pit 1 (Walem Madjawulu 1).

Date	Description of Event / Milestone
2022	Completion of final tailings from RWD to Pit 3 transfer via truck from remnant tailings.
2022	Commencement of ranger closure feasibility study refresh.
2022	Final drum of uranium oxide product sold on 31 May 2022.

2.1 Overview of completed operations and exploration

Mining activity at the Ranger Mine involved a conventional open cut process, commencing with drilling and blasting. Two open-cut pits were mined during the life of the Ranger Mine, Pit 1 and Pit 3 (Figure 2-1; Figure 2-3). Prior to the completion of mining in the pit's, mined material was categorised by a discriminator, measuring the uranium grade designated for either stockpiling or processing (Table 2-2; Figure 2-2; Figure 2-3). Low-grade ore and non-mineralised rock were stockpiled near pits 1 and 3 so it could be used in the future as backfill in the pits and to create the final landform.

Table 2-2: Indicative ore grades and mineral type

Grade	Grade (% U_3O_8)			Material type
	1980-1997	1998-2009	2010-Current	
1	<0.02	<0.02	<0.02	Non-mineralised rock
2	0.02-0.05	0.02-0.08	Low 2 0.02-0.06	Very low-grade ore
			High 20.06-0.08	Low-grade ore
3	0.05-0.10	0.08-0.12	0.08-0.12	ore
4	0.10-0.20	0.12-0.20	0.12-0.20	ore
5	0.20-0.35	0.20-0.35	0.20-0.35	ore
6	0.35-0.50	0.35-0.50	0.35-0.50	ore
7	>0.50	>0.50	>0.50	ore

Figure 2-1: Ranger Mine site

Figure 2-2: Ranger Mine plant layout

Legend

1. Car Park
2. Security
3. Bulk Fuel
4. Shellsol
5. Simon Carves Yard
6. Water Management Yard
7. Ammonia Handling
8. Emergency Dump Tank
9. Calciner & Product Packing
10. Solvent Extraction
11. Sand Filters
12. Administration
13. Water Management and Environmental Services
14. Engineering & Supply
15. Ranger 3 Deeps Portal
16. Decline Laydown Area
17. Closure Projects office
18. Sub Station
19. Demineralisation Plant
20. Power Station
21. Plant Services
22. Grinding
23. Counter-Current Decantation
24. Tailings Neutralisation & Process Water Header Tank
25. Corridor Road

26A. A - WTP 1

26B. B - WTP 2

27. Septic Transpiration Area
28. Acid Leach
29. Laterite Treatment Plant
30. Coarse Ore Stockpile
31. Fine Crushing
32. Secondary Crushing
33. BC Power Station & Control Room
34. Acid Storage
35. Brine Concentrator
36. Water Treatment Plant 3
37. Radiometric Sorting
38. Primary Crushing
39. Pond Water Tank
40. HDS Plant
41. Brine Squeezer
42. Lime Mill & Silos
43. Mine Wash Down
44. Retention Pond 2
45. Retention Pond 3
46. Mines Office
47. Old Orica Yard
48. Trial Evaporation Channels
49. Pit 1
50. Georgetown Creek Medium Bund Level (GCMBL)
51. Corridor Creek Land Application Area
52. Retention Pond 5
53. Corridor Creek Wetland Filter
54. Tailings Dam
55. Retention Pond 6
56. Trial Landform
57. Magazine
58. Retention Pond 1 Land Application Area
59. Retention Pond 1
60. Retention Pond 1 Wetland Filter
61. Retention Pond 1 Land Area Extension
62. Accommodation Camp
63. Workshop (Gagadju)
64. Jabiru East Land Application Area
65. Office of the Supervising Scientist
66. Telstra
67. Airport
68. Exploration Storage Yard
69. Jabiru East Potable Water Supply
70. Exploration Core Yard
71. Djalkmarra Land Application Area
72. Djalkmarra Land Application Area Extension
73. Pit 3
74. Levee
75. Magela Land Application Area
76. Borrow Pit
77. Djalkmarra Pumping Sump 12 (DJKPS12)
78. Exploration decline vent shaft

Energy Resources Of Australia

Ranger Mine

Mine Closure Plan 2022

Index for Site Layout Figures - Ranger Mine

Figure:	Drawing Number:	Revision:
2 - 3	22545_023	A.1

Drawn By:	Approved By:	Date:	Map Size:
J. Rivera	M. Ryan	29/09/2022	A3

0 675 1,350

Metres

Coordinate System: GDA 1994 MGA Zone 53

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Figure 2-3 Legend to Figure 2-1 and Figure 2-2

2.1.1 Pit 1 (Walem Madjawulu 1)

Construction of Pit 1 began in 1979. Mining of the orebody commenced in 1980 producing approximately 18 M t of ore between May 1980 and December 1994. The mined-out pit, generally circular in plan view, had a surface area of 41.1 ha and an approximate diameter of 750 m at the widest point. The benches were designed to be approximately 7 m high, except the first bench cut at 14 m. The final pit shell had the shape of an inverted cone, with a depth of -150 mRL[2].

Following the completion of mining, activities for the closure and rehabilitation of Pit 1 commenced. Closure and rehabilitation have been completed on Pit 1 with monitoring and adaptive management now being undertaken.

For information on Pit 1 tailings consolidation and solute egress modelling, refer to *Section 5 KKN supporting Studies*.

2.1.2 Pit 3

Approval for the construction of Pit 3 was received in May 1996. Open-cut mining commenced in July 1997. In 2008 ERA progressed with the Shell 50 pit expansion enabling mining of Pit 3 to continue until November 2012. The final pit shell had a base (floor) elevation of -265 mRL at its deepest point. At is its maximum surface extent, Pit 3 is approximately 1,750 m long and 970 m wide. The mine site is located within the Cahill Formation containing significant areas of uranium mineralisation within Lower Cahill metasediments.

In order to use the pit for tailings storage and to achieve a good rate of rise and consolidation of the tailings, the pit was backfilled with 33.7 Mt of low-grade ore and non-mineralised rock (termed underfill) to an approximate elevation of -100 mRL. The void within the underfill is being used for the storage of waste residue produced by the Brine Concentrator. An underdrain system comprising a 2 m layer of waste rock and a sump was constructed over the underfill to facilitate tailings consolidation and allow for the injection of brine.

A separate application has been submitted for Pit 3 closure activities.

2.1.3 Stockpiles

Several stockpiles comprising of low-grade ore and waste rock are situated within the vicinity of the mined pits and the RWD. As shown on Figure 2-1, the area covered by the stockpiles is approximately 2 km at its longest extent and 0.5 km in width. Approximately 21 M t of low-grade ore was processed from these stockpiles, and 104 M t of waste rock was stored for future use in backfilling both pits and to shape the final landform.

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[2] Reference Level abbreviated to RL denoting specific elevation relative to mean sea level and is regularly used to identify the height or depth of plan or mine infrastructure – e.g. the height of the RWD or depth of Pit 1.

Throughout the mine life, the stockpiles have been segregated according to both grade and material type (Table 2-2).

There are three main stockpile material types: primary, weathered and laterite. Primary material consists of unweathered host rock, comprised mainly of altered quartz-feldspar schists and to a lesser extent, cherts and carbonaceous materials. Weathered material consists of friable rock (usually quartz-feldspar schist) with altered mineral assemblages but generally still low in clay content. Laterite is a near-surface, highly weathered and sometimes reconsolidated material, typically high in iron and aluminium clays and other gangue minerals that have made it difficult to process conventionally. Early in the mine life, improved processing performance led to the combination of the weathered and the primary material being fed to the processing plant. In more recent years, a separate laterite processing circuit was constructed to process the weathered material.

2.1.4 Ranger 3 deeps exploration decline

The Ranger 3 (R3) Deeps orebody was discovered during surface drilling exploration in 2008. To better define the resource ERA constructed an exploration decline at the Ranger Mine adjacent to the south-eastern rim of Pit 3, from early May 2012 to December 2014 (Figure 2-4). This enabled an underground exploration and infill drilling program to increase orebody knowledge and provide geological, hydrogeological, geotechnical and radiological data.

The decline was extended, and the ventilation shaft was constructed between October 2013 and October 2014. Exploration diamond drilling began in May 2013. Preliminary drilling results were announced in August 2013, and the third drill rig was mobilised in November 2013. Drilling ceased in September 2014. In 2015 the decision was made to not progress, and the project was placed into care and maintenance.

The decline extends 2,700 m in length and 450 m below the ground surface, above and parallel to the target mineralised zone. The decline was intended to provide access to the mineral resource and subsequent underground mine known as 'Ranger 3 Deeps' (R3 Deeps).

In April 2019 ERA received approval from both the Commonwealth and Northern Territory Ministers to commence rehabilitation and closure of Ranger 3 Deeps. Details of the closure and rehabilitation of the decline are provided in Chapter 9.3.9 of *Section 9 Closure Implementation*.

Figure 2-4: Spatial extent of the Ranger 3 Deeps exploration decline

2.1.5 Processing

The major ore processing stages are described below.

- Uranium ore is crushed and ground, then the fine ore is mixed with water to produce a slurry;
- The ore slurry is pumped to leaching vessels where, over a period of 24 h, more than 90 % of the uranium in the ore is dissolved using sulfuric acid and pyrolusite (an oxidant);
- The uranium in solution is then separated from the depleted ore in a seven-stage washing circuit;
- After separation, the acidity of the depleted ore (tailings) is partially neutralised with lime before being pumped to the RWD, whilst the leach solution is clarified and filtered;
- The uranium is extracted from the leach solution and concentrated, and then pumped to precipitation tanks;
- A bright yellow uranium compound (ammonium diuranate), commonly referred to as 'yellowcake' is precipitated using ammonia;
- In the final stage of the process, the yellowcake is heated to 800 °C to produce the final product – uranium oxide, a dark green powder; and
- The product is packed into 200 L steel drums. These are sealed and transported by road, using an accredited transport company, to a secure holding facility and then exported by ship.

Following the completion of open cut mining in 2012, ERA continued to process stockpiled ore until 8 January 2021, when the Authority required processing to cease. The last drum of uranium oxide was sold on 31 May 2022, completing the mine's operational stage after producing a total of 132,000 tonnes of uranium oxide.

2.1.6 Process plant

The process plant area is shown in Figure 2-2 and includes all infrastructure associated with the processing of uranium ore and production of uranium oxide. Construction of the processing infrastructure began in 1979, and has since been replaced, upgraded, or added to over the life of the mine.

Following the cessation of processing activities on 8 January 2021, the process plant has commenced decommissioning and demolition activities as described in *Section 9 Closure Implementation*.

2.1.7 Tailings and process water storage

The Ranger Water Dam (RWD) formerly known as the Tailings Dam or Tailings Storage Facility (TSF), and Pit 1 and Pit 3, are approved to store tailings and process water in accordance with relevant conditions detailed in the Authorisation (*Section 3 Closure Obligations and Commitments*).

2.1.7.1 Ranger Water Dam

The Ranger Water Dam (RWD)[3] was commissioned as the Ranger Tailings Dam in 1980 classified as a “ring dyke” forming an approximate square with sides of about 1 km in length. The initial dam was based on a proposed crest level of 51.0 mRL[4]. Designed structural additions have increased the crest level to 60.5 mRL. The eastern, southern and western walls run along ridges that approximate catchment divides separating Coonjimba Creek from adjacent surface water catchments, including Gulungul Creek to the west and the Djalkmarra and Georgetown catchments to the east.

Neutralised mill tailings were deposited within the RWD from 1980 to 1996, after which time mill tailings were sent to the mined-out Pit 1 in accordance with regulatory approvals. Once Pit 1 reached its maximum tailings level, mill tailings were re-directed back to the dam from 2008 through to February 2015, when the mined-out Pit 3 became available for tailings storage. At this time, the tailings within the dam was estimated at 27 M t.

Tailings management was initially subaqueous due to concerns with radon gas emissions. In 1987 tailings deposition within the RWD was changed to sub-aerial due to: (a) studies which showed that radon gas emission was not an issue; and (b) concerns with low water levels causing the floating tailings pipelines to become stranded on tailings “islands”.

Details on the transfer of tailings from the RWD to Pit 3 and the rehabilitation activities associated with the closure of the RWD are provided in Chapter 9.3.3 of *Section 9 Closure Implementation*.

The free process water inventory held in the RWD is progressively reduced through passive evaporation and water treatment via the brine concentrator (BC).

Performance of the RWD is monitored, with annual inspections conducted by independent engineers, in accordance with the Authorisation and operated in accordance with the requirements of the Australian National Committee on Large Dams and International Commission of Large Dams guidelines for tailings dams design, construction, operation and closure (ANCOLD 2019). The data is reported to the Regulators to confirm that the structure continues to perform according to its design and operational criteria. All ERAs tailings storage facilities are operated in accordance with the Rio Tinto Standard D5: *Management of Tailings and Water Facilities* (Rio Tinto 2015), which covers all development phases from planning, design through construction, operation, closure and post-closure where applicable.

2.1.8 Water management

Water management is the most significant environmental and operational aspect of the Ranger Mine and is an integral part of the ERA Health, Safety and Environment Management System.

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[3] The Ranger Water Dam is the former Tailings Storage Facility (TSF) or Tailings Dam.

[4] Reference Level abbreviated to RL. Denotes a specific elevation relative to mean sea level and is regularly used to identify the height or depth of plan or mine infrastructure – e.g. the height of the RWD or depth of Pit 3.

It encompasses all aspects of water capture, storage, supply, distribution, use and disposal. Water is managed according to the Ranger Water Management Plan (RWMP), which describes the method used to control water on site (ERA 2022). The management plan, which fulfils the requirements of the Ranger Authorisation (0108-18) and is approved annually by regulators, outlines the approach ERA takes to:

- protect the wider environment, particularly Magela Creek and Gulungul Creek from the impacts of ERA operations;
- meet all current statutory requirements;
- manage water inventories and discharge mechanisms based on water quality according to the whole of mine approach rather than the source of the water;
- ensure data is collected to inform both operational and closure based decisions; and
- strategically manage process and pond water inventories in accordance with current closure planning and strategies.

Water at the Ranger Mine is categorised into different classes according to its source and composition (Appendix 2-1). Each class of water is managed in a specific way, in accordance with the Ranger Water Management System (Table 2-3).

Table 2-3: Water classes and their management

Water class	Description and treatment
Process water	The most impacted water class on site. Currently stored in the RWD (formerly the TSF) and Pit 3. The process water inventory is derived predominantly from water that has passed through or encountered the uranium extraction circuit, and rainfall from designated process water catchments.
Pond water	Water of a quality that requires active management. Derived from rainfall that falls on the active mine site catchments. The main storage facilities for pond water include Retention Pond 2 (RP2), RP3 and RP6.
Release water	Release water is derived from incident rainfall that falls on catchments within the mine footprint and is of a high enough quality that it is routed through passive treatment systems or staging points for management and release.
Potable water	Potable water is sourced from the Brockman Borefield located in the south-east of the RPA. A second production borefield (Magela Borefield) was established to the north of Jabiru East, primarily as a source of supply for Jabiru East and the Ranger Mine village. Grey water (e.g. from showers and toilets) is treated on site and pumped into septic tanks and then to leach drains.
Treated water	Treated water is water that has passed though one of the three water treatment plants, the Osmoflow Brine Squeezer (OBS) or through the Brine Concentrator (BC). Treated water is divided into the following categories: Water treatment plant permeate: Water that has been treated to remove a significant amount of its dissolved solids to allow it to be released.

Water class	Description and treatment
	BC distillate: Purified water that is produced by the BC. Treated distillate is subject to release criteria. OBS permeate: water derived from further reverse osmosis treatment of water treatment plant brines by the Brine Squeezer. Water quality is equivalent to water treatment plant permeate.
Reject streams	Water treatment plant brines: Water that contains the remaining dissolved solids removed from the pond water. Brines are typically discharged to the process water inventory. However, brines may be discharged to the pond water inventory based on operational requirements. BC brines: Residue water after the distillate has been extracted. OBS brines: residue water that contain the remaining dissolved solids removed from the treatment of pond water brines. Typically, discharged to the process water inventory or alternatively to pond water inventory based on operational requirements. High Density Sludge product water: water arising for the lime treatment process of the HDS plant to remove most salts present in process water. HDS product water may be either recycled to the process water inventory, or subject to further approvals, sent directly to the water treatment plants or discharged into the pond water inventory.

The Ranger Mine footprint is divided into catchment areas shown in Figure 2-5 that generate surface runoff and/or seepage as a result of incident rainfall. Each catchment may comprise of several elements including retention ponds, sumps, collection basins and groundwater interception ponds. The water circuit for the Ranger Mine, combining the five water classes, the different treatments and water management features, is shown in Figure 2-6. A description of the individual water management elements is provided in the following sections.

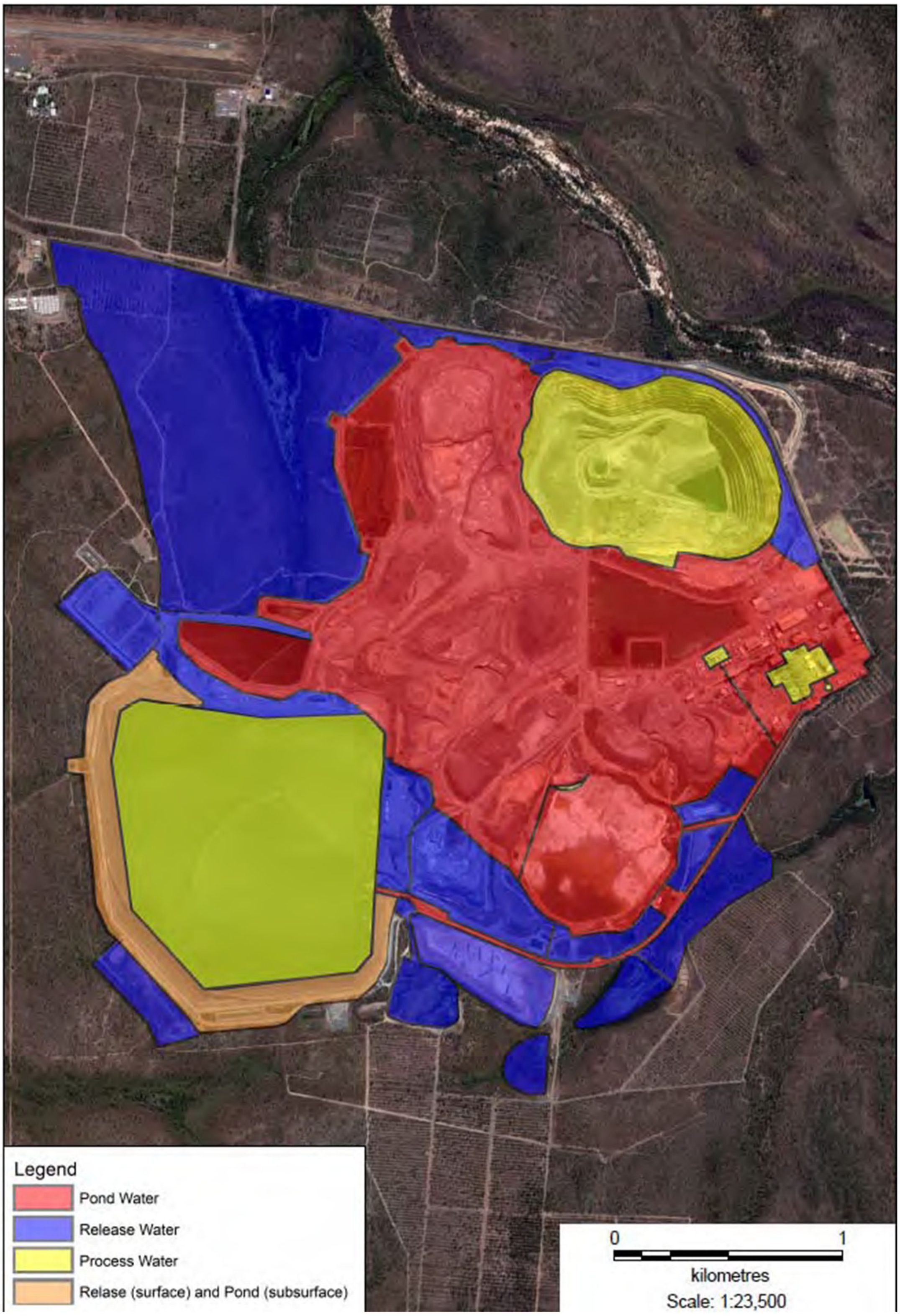

Figure 2-5: General arrangement of water class catchments on the RPA (Deacon, 2017)

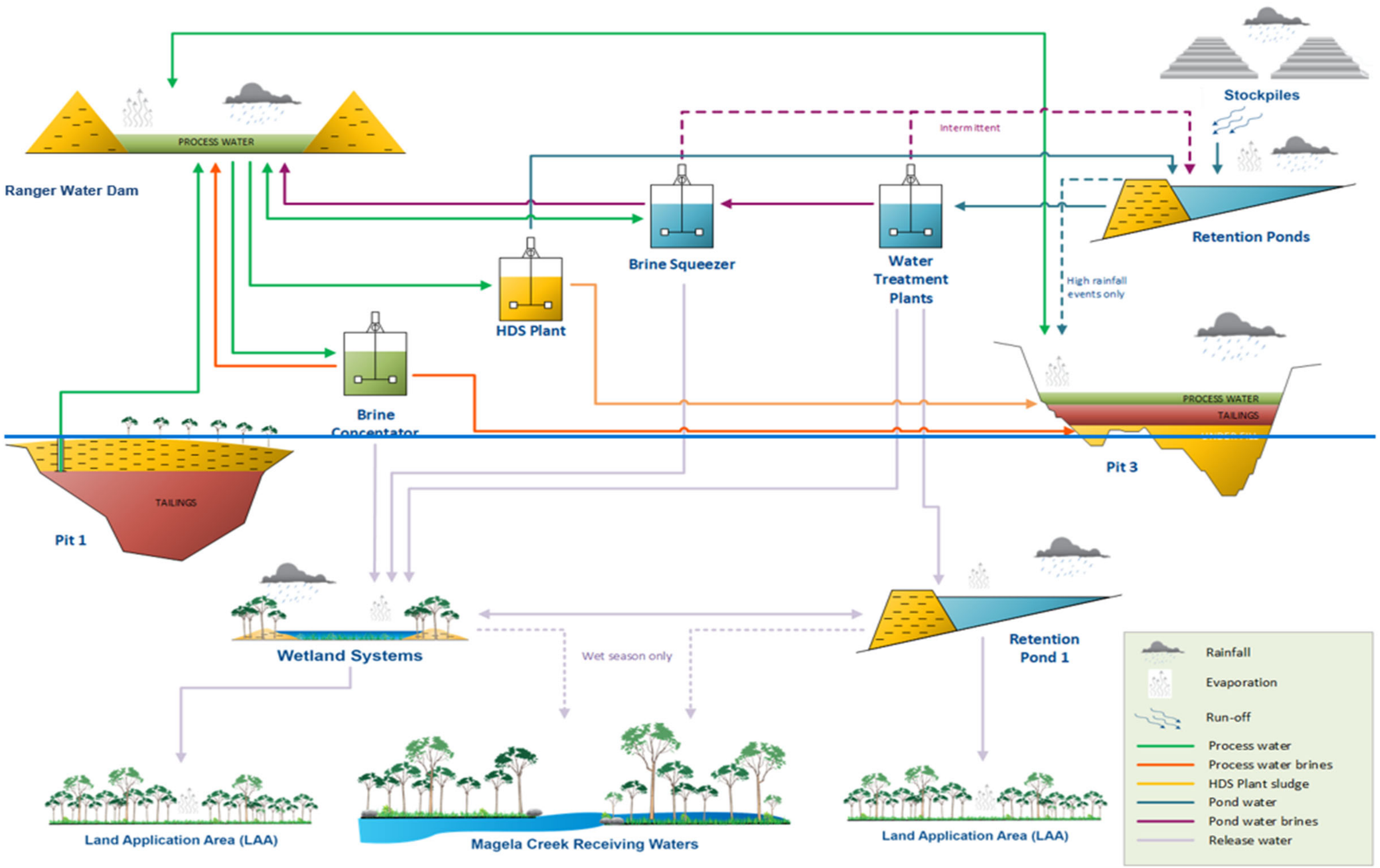

Figure 2-6: Ranger Mine water circuit

2.1.8.1 Retention ponds

Four retention ponds at the Ranger Mine provide sediment control, dilution and storage of pond and managed release waters (Figure 2-1):

- Retention Pond 1 (RP1) (capacity = 390 ML) an earthen embankment that dams Coonjimba Creek, and receives release quality water for discharge into Coonjimba Billabong (both passively and actively) or for active discharge into Magela Creek.
- Retention Pond 2 (RP2) (capacity = 1,150 ML) an earthen wall impoundment in the former Djalkmarra Creek catchment (now subsumed by Pit 3). RP2 is the primary storage of pond water with distribution networks to the water treatment elements.
- Retention Pond 3 (RP3) (capacity = 61 ML) an earthen impoundment within RP2. Water from RP3 is transferred to RP2 via a spillway and pumped for use on site.
- Retention Pond 6 (RP6) (capacity = 976 ML) a turkey-nested, double-lined pond that receives water from RP2 transfers and rainfall.

2.1.8.2 Wetland filters

The RP1 wetland filter comprises a series of earthen embankments forming an impoundment with discrete cells arranged in a series. The wetland filter has an ecosystem dominated by water lilies and native reeds (*Eleocharis* sp.). Upon entering the wetland, water flows through each of the cells under gravity over a path length of approximately 1,000 m. The last cell of the wetland filter can be equipped with a pumping station and a controlled overflow channel that spills to RP1.

The primary role of the wetland filter is to attenuate uranium from the water using biogeochemical processes before the water is discharged via passive flow to RP1, used in land application, operations for dust suppression or as construction water. RP1 wetland filter is currently removed from operational use and its operation will be assessed at a future date.

The Corridor Creek wetland filter is the only wetland filter currently in operation at the Ranger Mine (Figure 2-7 and Figure 2-8). This wetland filter is a combination of natural and constructed wetlands cells with a surface of approximately 17 ha and a total water volume of approximately 38 ML at full capacity. Constructed in 2001 and situated at the head of the Corridor Creek Catchment, the Corridor Creek wetland filter was designed primarily to passively treat (i.e. polish) ammonia from treated pond water permeate and uranium from surface water runoff. The Corridor Creek wetland filter is now used to re-mineralise and remove heat from the brine concentrator distillate (clean water from process water treatment, *Section 9 Closure Implementation*) and polish ammonia from distillate.

Figure 2-7: Corridor Creek wetland filter view one (CCWLF)

Figure 2-8: Corridor Creek wetland filter view two (CCWLF)

2.1.8.3 Land Application Areas

The Land Application Areas (LAAs) have been used at the Ranger Mine since 1985 and have a total area of approximately 350 ha. ERA defines land application as the process by which water (release water, permeate, wetland polished water) is applied to the LAAs through a network of distribution pipes and sprinkler heads, maximising evapotranspiration loss whilst minimising surface pooling and seepage, and preventing surface runoff during operations. Table 2-4 provides a generalised description of each operational LAA. Figure 2-9 shows all LAAs on the RPA, noting that Magela LAA was decommissioned in 2007. Further information on the studies undertaken in the LAAs is provided in *Section 5 KKN Supporting Studies* and a description of the rehabilitation to be carried out is provided in Chapter 9.3.4 of *Section 9 Closure Implementation.*

Table 2-4: LAA description of generalised water management

Land Application area	Description
4A Corridor Creek Land Application Area (CCLAA)	The CCLAA is comprised of a network of pipes and sprinkler heads located to the south of Pit 1. The area is approximately 135 ha. This area receives waters from Georgetown Creek median bund leveline (GCMBL) and Georgetown Creek Brockman Road (GCBR) and is operated during daylight hours only. There are no bunding requirements during active operation of CCLAA.
4C & D Djalkmarra Land Application Area (DLAA)	The DLAA is comprised of a network of distribution pipes and sprinkler heads set out across a tract of sparse native woodland north of the Pit 3 access road. The area is approximately 38 ha. This area receives permeate (via Coonjimba Billabong 2 catchment) only and is operated during daylight hours only. There are no bunding requirements during active operation of DLAA.
4E RP1 Land Application Area (RP1LAA)	The RP1LAA is comprised of a network of distribution pipes and sprinkler heads set out across a tract of disturbed sparse woodland to the west of RP1. The area is approximately 43 ha. This area receives release waters from RP1 and can be operated 24 hours a day and is suitable for flood irrigation. There are no bunding requirements during active operation of RP1LAA.
4F RP1 Extension Land Application Area (RP1Ext LAA)	The RP1Ext LAA is comprised of a network of distribution pipes and sprinkler heads set out across a tract of native woodland to the west of RP1. The area is approximately 8 ha. This area receives release waters from RP1 and is operated during daylight hours only. There are no bunding requirements during active operation of RP1 Ext LAA.
4G Jabiru East Land Application Area (JELAA)	The JELAA is comprised of a network of pipes and sprinkler heads that covers an area on the old Jabiru East town site. The area is approximately 52 ha. This area receives release waters from RP1 and is operated during daylight hours only. Whilst release quality water is used for irrigation on the JELAA there is no requirement for bunding.


4F
4C
4G
4D
4E
4B
4A
4A
Legend
Land Applications Areas
4A. Corridor Creek LAA
4B. Magelo LAA
4C. Djalkmarra LAA
4D. Djalkmarra LAA ext.
4E. Retention Pond 1 LAA
4F. Jabiru East LAA
4G. Retention Pond 1 LAA ext.
DARWIN
JABIRU
BATCHELOR
0
100 KM
Ranger Mine
Mine Closure Plan 2022
Land application areas at the Ranger Mine
Figure: 2 - 9
Drawing Number: 22545_029
Revision: A.1
Drawn By: J. Rivera
Approved By: M. Ryan
Date: 29/09/2022
Map Size: A3
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Figure 2-9: Land Application Areas

2.1.8.4 Water treatment infrastructure

ERA utilises a range of infrastructure to treat process and pond water and some reject streams at the Ranger Mine including:

- Three water treatment plants to treat excess pond water to a level suitable for release to the environment;
- The Brine Concentrator treats process water for release to Magela Creek, via the Corridor Creek system (Figure 2-10);
- The Brine Squeezer provides an additional stage of treatment for pond water through the water treatment plants; and
- The High Density Sludge (HDS) plant treats process water to a water quality similar to pond water (Figure 2-11).

Further details on the water treatment infrastructure and process can be found in *Section 9 Closure Implementation*.

Figure 2-10: Brine Concentrator

Figure 2-11: High Density Sludge plant at Ranger Mine

2.1.8.5 Treated water release

Wet season release

Discharge of treated pond water can be to RP1, Collection Basin 2 (CB2), Corridor Creek Wetland Filter (CCWLF) system and GCMBL in accordance with regulatory approvals, where applicable. Water can be released from the RPA to the environment from the following locations:

- Collection Basin 7 (CB7);
- Djalkmarra Pump Station 12 (DJKPS12);
- Djalkmarra Release Point (DJKRP), treated pond water (WTP permeate) and distillate only;
- Georgetown Creek 2 (GC2); and
- RP1.

To assist in managing potential impacts to Magela Creek, all these locations are incorporated in the Release Plan Calculator (RPC) to assist with determining water quality at MG009 during releases.

Irrigation, dry season release:

In the dry season, ERA irrigates to the Land Application Areas (LAAs). Land application follows the general principles of maximising evapo-transpiration loss, minimising surface pooling and seepage as well as preventing surface run-off during operations.

2.1.9 Site water model

Water management and closure planning at the Ranger Mine has been supported since 2006 by a dynamic water and solute balance model. The model considers the characteristics, connectivity and operational rules associated with the material elements of the process and pond water circuits at the Ranger Mine, and the planned changes to the nature of those elements through to completion of closure. Elements include process and pond water catchments and storages, water treatment plants, the BC, HDS plant and other planned additional process water treatment facilities. The model also contains approximations for the release water catchments and storages, and the facilities and rules for managed release to the environment.

The understanding of the site's water systems, as captured in the model, was routinely tested during the site’s operating phase by an annual validation and calibration process. This process took advantage of the extensive array of water related measurements around the RPA to reconcile model predictions against actual observations and provide updates to the model to address any identified variations.

The forecasting approach applies multiple sequential periods of historical daily rainfall data to the model as an estimate of the possible variation in future rainfall. Model results are collected for each period, simulated, and statistically analysed to provide confidence traces for each variable of interest.

The historical rainfall data for the forecast has been sourced from a point interrogation ('data drill') at a geographic point corresponding to Jabiru Airport, of a climate database prepared by the Science Delivery Division of the Queensland Government Department of Science, Information, Technology and Innovation (Jeffrey *et al.* 2001). The current rainfall data set in use commences on 1 January 1889 and runs through to June 2022.

Typically, median forecasts are used for planning across closure timeframes, with higher confidence forecasts (generally corresponding to higher rainfall) used for contingency and capacity planning. The model's forecasts for the inventory of free process water in the TSF and Pit 3 over time are presented in Figure 2-12.

Revisions continue to be made to the water model in response to updated measurements of site process water inventory and changes in closure plan tactics.

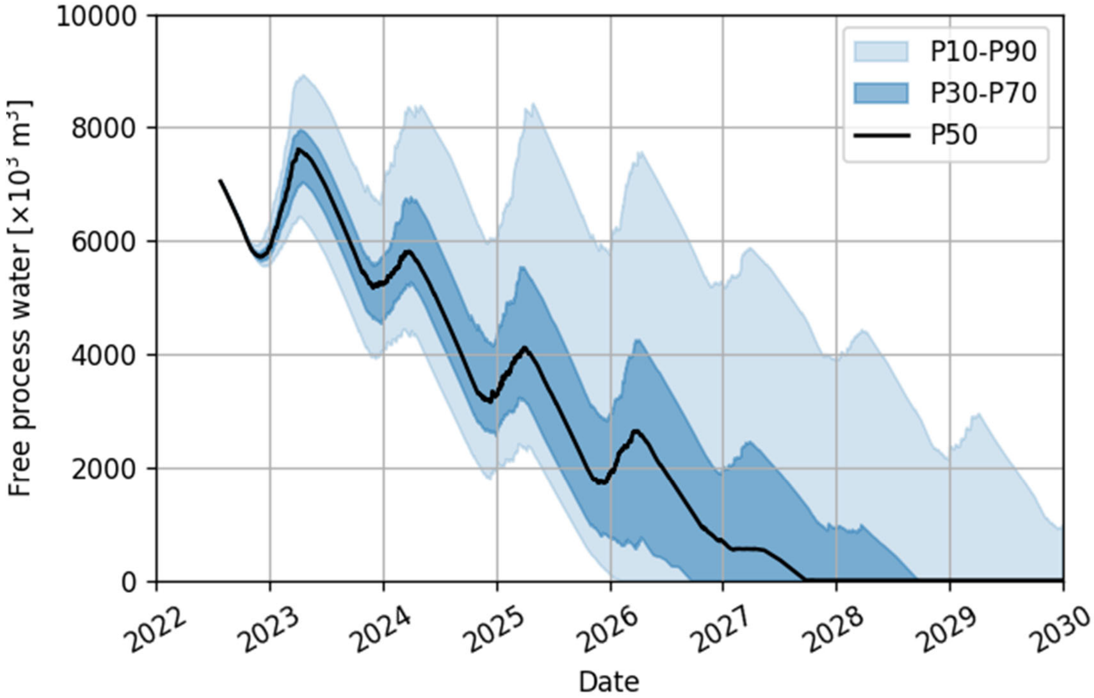

Figure 2-12: Site water model free process water inventory forecast (August 2022)

References

Australian National Committee on Large Dams (ANCOLD) 2019. *Guidelines on Tailings Dams.* Planning, Design, Construction, Operation and Closure – Revision 1.

Deacon, J., 2017. *Ranger Water Management Plan 2016/17*. Energy Resources of Australia Ltd (ERA), Darwin. Report # RWMP002, Revision 2.16.0, Commercial in Confidence.

Energy Resources of Australia Ltd (ERA) 2022. *Ranger Water Management Plan*. Energy Resources of Australia Ltd. Darwin. 10 February 2022.

Fox, R, Kelleher, G & Kerr, C 1976. *Ranger Uranium Environmental Inquiry: First Report.* Australian Government Publishing Service, Canberra, pp. 206.

Fox, R, Kelleher, G & Kerr, C 1977. Ranger Uranium Environmental Inquiry: Second Report. Australian Government Publishing Service, Canberra, pp. 415.

Jeffrey, S, Carter, J, Moodie, K & Beswick, A 2001. *Using spatial interpolation to construct a comprehensive archive of Australian climate data.* Environmental Modelling and Software, Vol 16/4. 2001, pp 309-330.

Rio Tinto 2015. *D5 Standard: Management of tailings and water storage facilities*.

APPENDIX 2-1 WATER MANAGEMENT TERMINOLOGY

TERM	DEFINITION
Water Classes	The separation of site water volumes based on their source, properties and management requirements. For the Ranger Mine, the defined water classes include: process water, pond water, release water and potable water.
Process water	Water that has either passed through the uranium extraction circuit; has come into contact with the processing circuit (i.e. milling, leaching, solvent extraction); or has come into contact with a process water storage facility (i.e. TSF, Pit 1 underdrain and Pit 3). Process water quality is characterised by high dissolved solids. Process water must be contained on site unless treated via an approved treatment process.
Pond water	Water derived from rainfall on active mine-site catchments or disturbed surfaces, which subsequently needs to be actively managed or treated before it can be disposed to the environment.
Release water	Water derived from the runoff from undisturbed catchments within the mine footprint and from the various water treatment product streams, which is of a quality suitable for disposal to the environment.
Potable water	Water that is used for drinking and ablution purposes, including safety showers, and parts of the plant where high quality water is required, such as within the demineralisation plant.
Water Management System	All the infrastructure and operations required to manage water on site. This includes capturing, storing, transferring, treating and disposing water.
Storage Facility	A designated area or structure where water of a particular class will be contained prior to future transfer, treatment or disposal.
Retention Pond	A large artificial pond that collects runoff and stores pond water prior to treatment (RP2, RP6) or stores release water prior to discharge to the environment (RP1).
Collection basin	A small artificial basin that captures runoff from a localised area, for immediate transfer onward to a retention pond.
Treatment Facility/Process	Infrastructure designed to treat water of a particular class through to a higher quality product.
Brine Concentrator (BC)	A treatment plant that uses mechanical vapour recompression technology to evaporate process water, producing a clean product stream (distillate) suitable for disposal to the environment, and a waste stream called Brine Concentrator brine.
Water Treatment Plant (WTP)	One of three ultrafiltration/reverse osmosis treatment plants that treats pond water to produce a clean product stream (permeate) suitable for disposal to the environment and a waste stream (WTP brine).

TERM	DEFINITION
Brine Squeezer (BS)	A reverse osmosis plant that further processes WTP brine to recover additional permeate. The waste product (Brine Squeezer brine) is considered process water.
High Density Sludge (HDS) plant	A plant that treats process water with lime to produces a moderately clean product stream (HDS product) that can be considered pond water, and a waste stream (HDS sludge).
Wetland filter	An artificial wetland that can receive mildly contaminated water and treat it so that it can be considered release water.
Land Application Area	A designated area where irrigation of release water may occur during the dry season.
Treatment products	
BC distillate	The clean product resulting from treatment of process water through the BC. Considered release water.
WTP permeate	The clean permeate from treatment of pond water through one of the three WTPs. Considered release water.
Brine Squeezer permeate	The clean permeate from treatment of WTP brine or process water through the Brine Squeezer. Considered release water.
HDS product	The product water stream arising from treatment of process water through the HDS plant. Considered pond water.
Treatment wastes	
WTP brine	The brackish liquid waste arising from treatment of pond water through one of the three WTPs. WTP brine is either recycled to pond water, further processed by the Brine Squeezer or directed to process water.
BC brine	The concentrated salt liquid waste arising from treatment of process water through the BC. BC brine is either recycled to process water or injected into the underfill of Pit 3.
Brine Squeezer brine	The salty liquid waste arising from treatment of WTP brine or process water through the Brine Squeezer. Directed to process water.
HDS sludge	The alkaline waste slurry arising from treatment of process water through the HDS plan. This is directed to Pit 3 for final disposal.